PATENT ABSTRACTS OF JAPAN

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(21)Application number : 08-143685 (71)Applicant : CANON INC

(22)Date of filing : 14.05.1996 (72)Inventor : HORIUCHI AKINAGA

(54) REAR FOCUS TYPE ZOOM LENS

(57)Abstract:

PROBLEM TO BE SOLVED: To improve optical performance over the whole object distance and over the entire variable power rangeand to realize a large aperture and high variable power by specifying the lens constitution of respective lens groups in the constitution of a four-group type one.

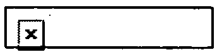
SOLUTION: This lens is provided with four lens groupsthat isthe 1st group L1 to the 4th group L4 in order from the object side. The variable power from the wide angle end to the telephoto end is performed by moving the 2nd group L2 to an image surface sideand the variation of the image surface associated with the variable power is corrected by moving the 4th group L4 to the object side while keeping projecting loci 4a and 4b providedand focusing is performed by moving the 4th group L4. The 4th group L4 is provided with a 1st lens being positivea 2nd lens being negative and a 3rd lens being positiveand has at least one aspherical surface. When it is assumed that the focal distance of the 3rd group L3 is f3the f-number and the focal distance of an entire system at the wide angle

end are fNW and fW and the focal distance of the entire system at the telephoto end is fT and they are set as shown by an expression fM=(fW.fT)1/2; they satisfy the condition of 3.44<f3×fNW/fM <15.38.

CLAIMS

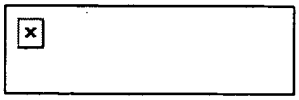
[Claim(s)]

[Claim 1]The 1st group of refracting power more positive than the object side to orderthe 2nd group of negative refracting powerthe 3rd group of positive refracting powerAnd have four lens groups of the 4th group of positive refracting powermove this 2nd group to the image surface sideand variable power from a wide angle end to a tele edge is performedMove this 4th grouphaving a convex locus in the object sideand amend image surface fluctuation accompanying variable powerand move this 4th group and a focus is performedThis 4th group has the 41st positive lensthe 42nd negative lensand the 43rd positive lensthis 4th group has at least one aspheric surfaceand a focal distance of the whole system [in / for the f number and a focal distance of the whole system / fNWfWand a tele edge] is respectively set to fT[in / for a focal distance of this 3rd group / f3 and a wide angle end] [Equation 1]



The zoom lens of the rear focus type satisfying the conditions which become 3.44<f3xfNW/fM<15.38 when it sets.

[Claim 2]A focal distance of composition from said 1st group [in / respectively / for a focal distance of the whole system in a wide angle end and a tele edge / fWfTa wide angle endand a tele edge] to the 3rd group is respectively set to fMWfMT[Equation 2]



A zoom lens of a rear focus type of Claim 1 satisfying conditions which become 0<fM/fAM<1.0 when it sets.

[Claim 3]the [31st negative in said 3rd group lens32nd positive lens / of the shape of meniscus which turned a convex to the image surface side /and at least one lamination] -- a zoom lens of a rear focus type of Claim 1 having 3a lens.

[Claim 4]A zoom lens of a rear focus type of Claim 1 satisfying nud>66.5 when setting an Abbe number of construction material of at least two positive lenses in said 4th group to nud.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention]A photographic camera and a video camera with the long back focus which is a grade to which especially this invention can arrange a color separation prism etc. between a lens system and an image sensor about the zoom lens of a rear focus typeAnd it is related with the zoom lens of the rear focus type of a high variable power ratio by the variable power ratio 15.5 and the about 1.45 to 1.65 f number [of a wide angle end] large caliber ratio which are used for the camera for broadcastetc.

[0002]

[Description of the Prior Art]These daysin connection with small weight savingssuch as a home video cameraremarkable progress is looked at by the miniaturization of the zoom lens for an image pick-upand power is especially directed towards shortening of whole length of the lensthe miniaturization of a front ball diameterand simplification of composition.

[0003]The so-called zoom lens of the rear focus type which moves lens groups other than the 1st group by the side of an objectand performs a focus as one means to attain these purposes is known.

[0004]Generally compared with the zoom lens which the zoom lens of a rear focus type moves the 1st groupand performs a focusthe effective diameter of the 1st group becomes smallThe miniaturization of the whole lens system becomes easyand there are the featureslike close photographingespecially since close photographing becomes very easy and it is carrying out by moving a further comparatively small lightweight lens groupthe driving force of a lens group is smalland endsand quick focusing is made.

[0005]As a zoom lens of such a rear focus typefor example JPS62-215225AIn JPS62-206516AJPS62-24213AJPS63-247316Aand JPH4-43311A. The 1st group of refracting power more positive than the object side to orderthe 2nd group of negative refracting powerthe 3rd group of positive refracting powerAnd the zoom lens of the 4 group type rear focus type which had four lens groups of the 4th group of positive refracting powermoved the 2nd groupperformed variable powermoved the 4th group and performed the image surface fluctuation accompanying variable power and a focus is proposed.

[0006]As a zoom lens of a 4 group type rear focus typein JPH4-43311AJPH4-153615AJPH5-19165AJPH5-27167Aand JPH5-60973A. The zoom lens with short whole length of the lens which constituted the 4th lens group from one positive lens or two positive lenses is proposed. In JPH5-60974Athe zoom lens with which the 4th lens group comprised two sheetsa positive lens and a negative lensis proposed.

[0007]JPS55-62419AJPS62-24213AJPS62-215225AJPS56-114920AJPH3-200113AJPH4-242707AJPH4-343313AIn JPH5-297275Athe zoom lens with which each changes the 3rd group and the 4th group from two lensesa positive lens and a negative lensin the working example is indicated.

[0008]In addition to thisIn JPH6-51199AJPH6-337353AJPH6-347697Aand JPH7-270684Abetween a lens system and an image sensor. The zoom lens with the long back focus which is a grade which can arrange a color separation optical system is proposed.

[0009]

[Problem(s) to be Solved by the Invention]The featureslike if a rear focus method is generally adopted in a zoom lensthe whole lens system will be miniaturizeda focus quick again will become possibleand also close photographing becomes easy are acquired.

[0010]Howeverthe problem that the aberration variation in the case of a focus becomes largeand it becomes very difficult to obtain high optical performance covering the object distance at large [from an infinite distance object to a short distance object] on the other hand arises.

[0011]The problem that it becomes very difficult to migrate to all the variable power ranges with the zoom lens of high variable power especially by a large caliber ratioand to obtain high optical performance covering the object distance at large arises.

[0012]With the zoom lens currently indicated by JPH4-43311AJPH4-153615AJPH5-19165AJPH5-27167Aand JPH5-60973Aa zoom ratio is about 8 times from 6 timesIf it is going to obtain the zoom lens of the high variable power ratio beyond thischange of the chromatic aberration by variable power will become large too muchand it will become difficult to amend this good. As for the zoom lens currently indicated by JPH5-60974Aabout 8 times was not necessarily enough as the zoom ratio.

[0013]In the zoom lens currently indicated by JPS55-62419AJPS56-114920Aand JPH3-200113Ain order that the 1st group or the 3rd group might move in connection with variable powerlens barrel structure became complicatedand there was a problem that it was difficult to attain a miniaturization.

[0014]With the zoom lens currently indicated by JPH4-242707A and JPH4-343313AJPH5-297275Aetc.the 3rd group serves as lens constitution with big air spacingSince the refracting power of the negative lens in the 3rd group was still weakerwhen it was going to apply to the zoom lens of high-variable-power-izingmany chromatic aberrations occurred by the 3rd groupand there was a problem that it was difficult to fully amend this.

[0015]Since the negative lens of the shape of meniscus in the 3rd group serves

as lens constitution which turned the concave surface strong against the image surface side in the zoom lens proposed by JPH5-297275Ait is effective in the formation of a tele photographbut. There was a problem that it was difficult for this negative lens to amend the high order flare components generated with the positive lensand large-caliber-izing and high-variable-power-izing were difficult.

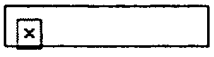
[0016]In additionas for the zoom lens proposed by JPH6-51199AJPH6-337353AJPH6-347697AJPH7-270684Aetc.about 10 to 12 times was not necessarily enough as the zoom ratio.

[0017]In the zoom lens of a 4 group type rear focus type this inventionthe object distance from an infinite distance object to [migrates to all the variable power ranges from a wide angle end to a tele edge by setting up the lens constitution of each lens group appropriatelyand] a super-near object -- crossing generally -- fitness -- it aims at offer of the zoom lens of the rear focus type of a high variable power ratio by a large caliber ratio with optical performance.

[0018]

[Means for Solving the Problem]A zoom lens of a rear focus type of this inventionThe 1st group of refracting power more positive than the object side to orderthe 2nd group of negative refracting powerthe 3rd group of positive refracting powerAnd have four lens groups of the 4th group of positive refracting powermove this 2nd group to the image surface sideand variable power from a wide angle end to a tele edge is performedMove this 4th grouphaving a convex locus in the object sideand amend image surface fluctuation accompanying variable powerand move this 4th group and a focus is performedThis 4th group has the 41st positive lensthe 42nd negative lensand the 43rd positive lensthis 4th group has at least one aspheric surfaceand a focal distance of the whole system [in / for the f number and a focal distance of the whole system / fNWfWand a tele edge] is respectively set to fT[in / for a focal distance of this 3rd group / f3 and a wide angle end] [0019]

[Equation 3]



3.44<f3xfNW/fM<15.38 when it sets .... (1)

It is characterized by satisfying becoming conditions.

[0020]

[Embodiment of the Invention]As for the lens sectional view of numerical working example 1-3 whichas for drawing 1 - drawing 3the zoom lens of the rear focus type of this invention mentions laterdrawing 4 - drawing 6numerical working example 2drawing 10 - drawing 12 of numerical working example 1drawing 7 - drawing 9 are the several aberration figures of numerical working example 3.

[0021]In an aberration figuredrawing 4and 7 and 10 show eighta wide angle enddrawing 5and 11 show nineand middledrawing 6and 12 show a tele edge.

[0022]As for the inside L1 of a figurethe 1st group of positive refracting powerthe 2nd group of refracting power negative in L2the 3rd group of refracting power positive in L3and L4 are the 4th group of positive refracting power. SP is an aperture diaphragm and is stationed ahead of the 3rd group L3. G is glass blockssuch as a color separation optical systema faceplatea filter. IP is the image surface.

[0023]In this exampleon the occasion of the variable power from a wide angle end to a tele edgethe 2nd group is moved to the image surface side like an arrowand the 4th group was moved having a convex locus in the object sideand the image surface fluctuation accompanying variable power is amended.

[0024]The rear focus type which moves the 4th group on an optic axis and performs a focus is adopted. The curve 4a of the solid line of the 4th group and the curve 4b of a dotted line which are shown in the figure show the moving track for amending the image surface fluctuation at the time of following on the variable power from a wide angle end when carrying out the focus to the infinite distance object and the short distance object respectively to a tele edge. The 1st group and the 3rd group are immobilization in the case of variable power and a focus.

[0025]In this examplemove the 4th group and the image surface fluctuation accompanying variable power is amendedand the 4th group is moved and it is

made to perform a focus. It is made to move so that it may have a convex locus to the object side on the occasion of the variable power from a wide angle end to a tele edgeas shown especially in the curves 4a and 4b of the figure. This aimed at effective use of the space of the 3rd group and the 4th groupand shortening of whole length of the lens is attained effectively.

[0026]In this examplewhen performing a focus from an infinite distance object to a short distance object in a tele edgeit is carrying out by letting out the 4th group to the frontas shown in the straight line 4c of the figure.

[0027]In this inventionin order this 4th group from the object side The 41st lens positive [convex] in both lens sidesThe 42nd negative lens and both lens sides of the shape of meniscus by which both lens sides turned the convex to the concave surface or object side consist of three lenses of the 43rd convex positive lensand it is characterized by having satisfied the conditional expression (1).

[0028]The position (distance) of an exit pupil is lengthened by constituting the 4th group from three lenses like the abovethe emitted light flux from a lens system -- a call -- as it becomes centricthe degree of incidence angle of light flux when the color separation optical system of 3P prism etc. has been arrangedfor example separates the color by [as becoming loose] good behind a lens systemand he is trying to improve the color reproduction nature of a picture to it

[0029]And in order to amend the aberration at the time of attaining large-caliber-izing and high-variable-power-ization goodsecuring the back focus of predetermined lengtheach element is set up so that the refracting power (focal distance f3) and the f number of the 3rd group may satisfy a conditional expression (1).

[0030]This conditional expression (1) regulates the focal distance f3 of the 3rd groupand is greatly related to a back focus.

[0031]If the f number FNW of a wide angle end is made bright exceeding the lower limit of a conditional expression (1) or the focal distance of the 3rd group is shortenedit will become difficult to secure the back focus of predetermined length. Converselyif the focal distance of the 3rd group is recklessly lengthened

exceeding upper limit or the f number FNW of a wide angle end is made darka back focus will become longbut distance with the 4th group becomes longwhole length of the lens becomes longand a miniaturization becomes difficult.

[0032]The feature of the other lens constitution of the zoom lens of the rear focus type of this invention is explained.

[0033](b) This invention sets high variable power as one purposeandas for the chromatic aberration generated in connection with variable power for the purposeit is desirable to cancel in the 1st group and the 2nd group. Howeverthe methods of generating of the chromatic aberration of the magnification accompanying variable power differ greatly at it of the 1st group and the 2nd groupand it is easy to become the tendency for amendment to be superfluous in a wide angle end. Thereforethe balance of the chromatic aberration as the whole is maintained by supposing that amendment of the chromatic aberration of the magnification of the 4th group is insufficient.

[0034]In this caseit is possible to amend without losing balance greatlywhen the chromatic aberration on an axis has a small variable power ratio. Thereforealthough it is also possible to use the 3rd group as a positive single lenswhen aiming at high variable power and a large caliber like this inventionit becomes difficult it to become insufficient as a whole amending the chromatic aberration on an axisand to maintain high performance.

[0035]the [then/ 32nd positive lens / of the shape of meniscus which turned the convex to the 31st negative lens and image surface side for the 3rd group in this invention /and at least one lamination] -- the chromatic aberration is amended to optimum over all the variable power ranges by constituting from a 3a lens. The spherical aberration with high order flare components is suppressed small.

[0036]The negative meniscus-like 31st lens with which both lens sides turned the convex to the concave surface or object side especially for the 3rd groupIt is considered as the lamination lens which consisted of the 32nd positive lens of the shape of meniscus which turned the convex to the image surface sidethe 33rd lens positive [convex] in both lens sidesand the 34th negative lens of the

shape of meniscus which turned the convex to the image surface sideamong these joined the 33rd lens and the 34th lens.

[0037]Thusin this inventionthough it is easy lens constitutionit is the about 1.45 to 1.65 f number of the variable power ratio 15.5 and a wide angle endand a high variable power ratio and a large caliberand moreoverhigh optical performance is maintained.

[0038](**) if the composition which joins a lens in the lens constitution of each group fundamentally is takenit is possible to be able to control the eccentricity in a group effectively and to attain stabilization of product performancebut one flexibility of a design decreasesand it becomes difficult to attain sufficient initial performancesatisfying a large caliber and specification called small zoom.

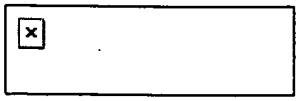
[0039]Thenby giving the aspheric surface of shape where positive refracting power becomes weak as the 3rd group is constituted from this invention like the above-mentioned and it goes for the convex of the strongest positive refracting power in the 3rd group by numerical working example 1 around a lensThe high order flare components of the spherical aberration were amendedand control of the eccentricity in a groupetc. was performed effectivelyand the higher-precision zoom lens has attained large caliber-ization. By constituting the 4th group from drawing 1 and numerical working example 1 and 3 of drawing 3 so that it may have a cemented lenscontrol of the eccentricity in a groupetc. was effectively performed like the 3rd groupand the higher-precision zoom lens is attained.

[0040]In this inventionthough a spherical aberration and astigmatism are amended and it is a large caliber and a twice [super-high] as many zoom lens as this when positive refracting power adopts the aspheric surface of the shape which becomes weak as it goes for the convex of the strongest positive refracting power in the 4th group to a lens peripherythe high-precision zoom lens is attained.

[0041](**) Set respectively the focal distance of composition from said 1st group [in / respectively / for the focal distance of the whole system in a wide angle end and a tele edge / fWfTa wide angle endand a tele edge] to the 3rd group to

fMWfMT[0042]

[Equation 4]



It is 0<fM/fAM<1.0 when it sets..... (2)

It is satisfying the becoming conditions.

[0043]A conditional expression (2) means the convergence degree of the bundle of rays from the 3rd group. the bundle of rays generally emitted by variable power parts -- the 3rd group -- abbreviated -- it is the most stable aberration correcting method to make it afocal. Howeverif the bundle of rays which comes out from the 3rd group is made into an almost parallel beam of lightshortening of whole length of the lens will become difficult. Thenby satisfying a conditional expression (2) to this inventionshortening of the further whole length of the lens is attained by making into a convergence beam of light the bundle of rays ejected from the 3rd group.

[0044]If a meaning of a conditional expression (2)i.e.a lower limitis exceededsince it becomes an emission systemand whole length of the lens is extended and also height of incident light to the 4th group also becomes a bundle of rays highin order that the 4th group may enlargeit is not preferred. If upper limit is exceededthe degree of convergence will become largean aberration variation by zooming and focusing which an effect goes up to a miniaturization will become largeand it becomes difficult to perform good aberration compensation throughout zoom.

[0045]In this inventionit is upper limit of a conditional expression (2)

0<fM/fAM<0.3 ..... (2a)

Thencoexistence of shortening of stable aberration compensation and whole length of the lens becomes easy.

[0046](**) nud>66.5 when setting an Abbe number of construction material of at least two positive lenses in said 4th group to nud .... (3)

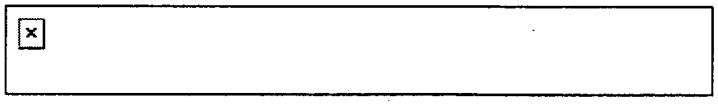
It is satisfied.

[0047]A conditional expression (3) is a thing for mainly amending change of a chromatic aberration accompanying variable powerespecially change of the chromatic aberration of magnification good. Since it will become insufficient amending the chromatic aberration of magnification if it separates from a conditional expression (3)it is not good.

[0048]Nextnumerical working example of this invention is shown. in numerical working example -- Ri -- the 1st conjugate point side -- it is a curvature radius of the i-th lens sideandas for Dithe i-th lens thickness and air spacingnickeland nui are a refractive index and an Abbe number of glass of the i-th lens in order from the 1st conjugate point side of each in the 1st conjugate point side. Howevera lens side of R28-R35 in R27-R34 in numerical working example 1 and 3and numerical working example 2 shows glass blockssuch as a color separation optical systema faceplateand a filter.

[0049]When aspherical surface shape makes positive a direction of movement of a Y-axis and light to the X-axisan optic axisand a perpendicular direction at an optical axis direction and a paraxial curvature radiusKBCDand E are respectively made into an aspheric surface coefficient for R[0050]

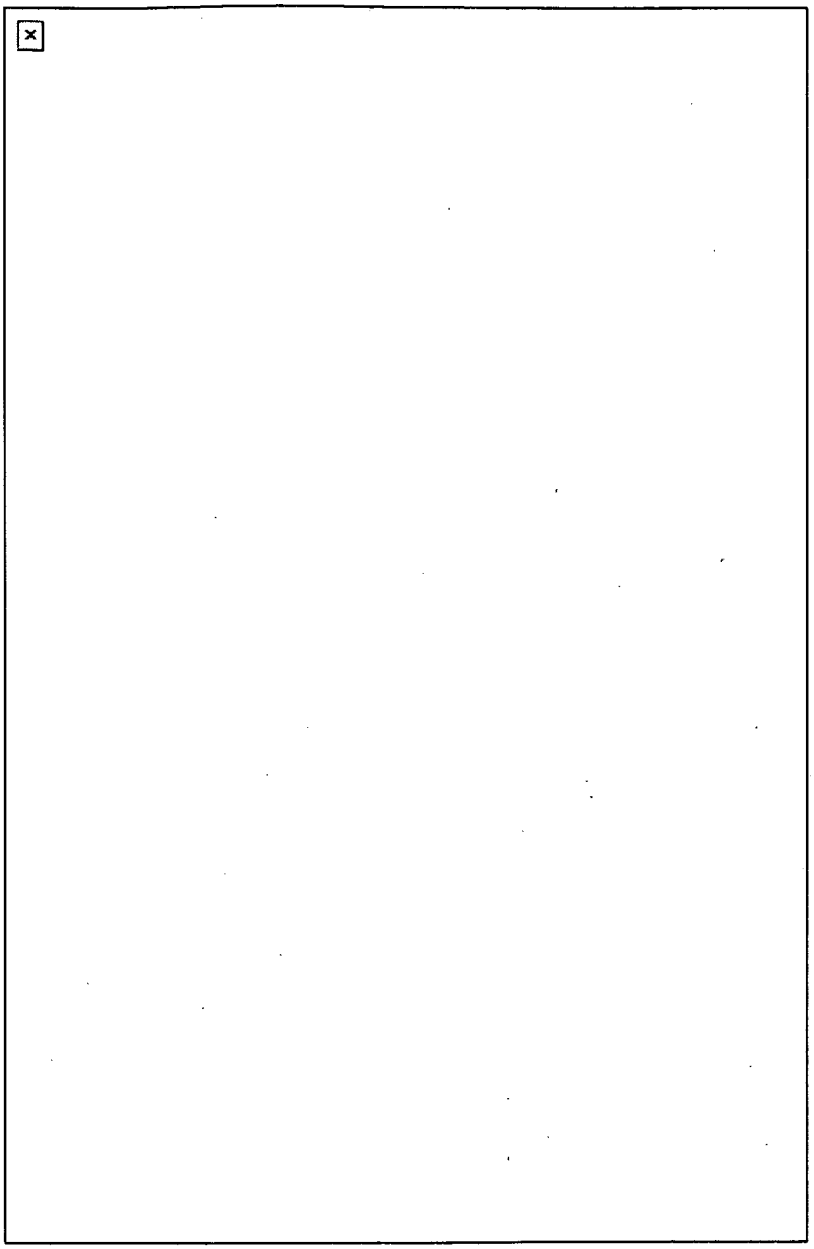
[Equation 5]



It expresses with the becoming formula. "e-0x" means "10^{-x}." The relation of many numerical values in an above-mentioned monograph affair type and numerical working example is shown in table-1.

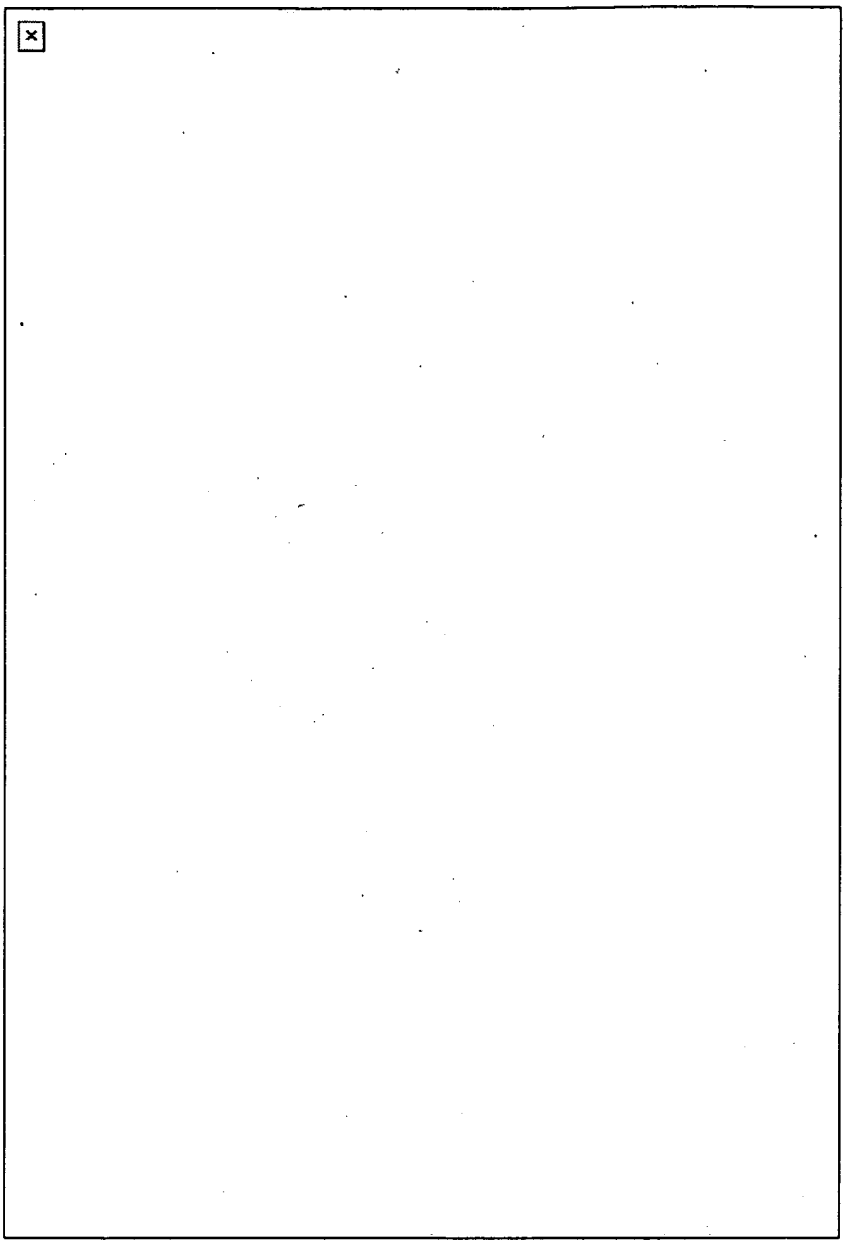
[0051]

[External Character 1]



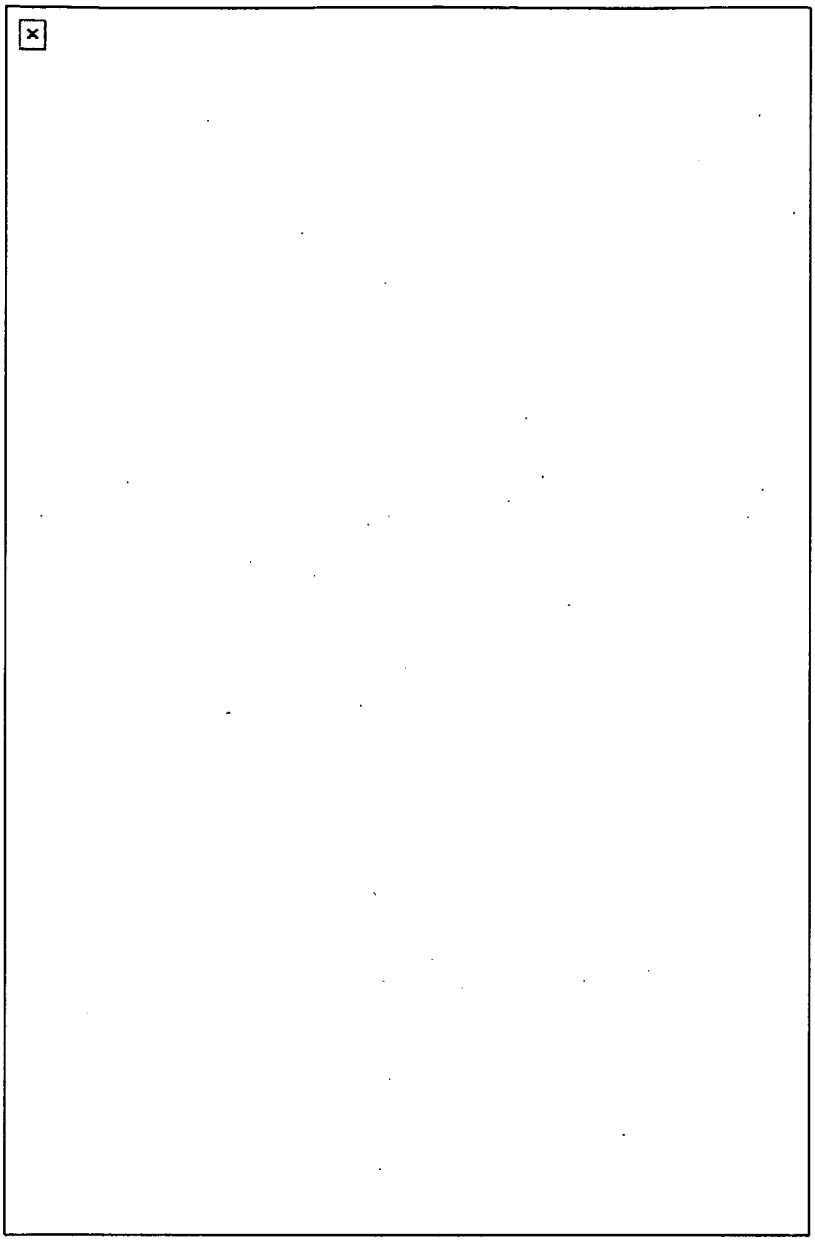
[0052]

[External Character 2]



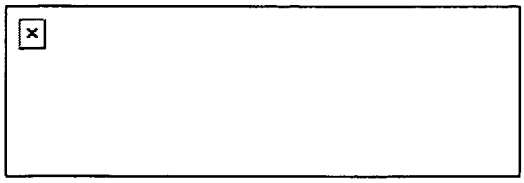
[0053]

[External Character 3]



[0054]

[Table 1]



[0055]

[Effect of the Invention]In [according to this invention] the zoom lens of a 4 group type rear focus type as mentioned aboveBy setting up the lens constitution of each lens group appropriatelythe object distance at large [from an infinite distance object to / migrates to all the variable power ranges from a wide angle end to a tele edge and / a super-near object] can be coveredand the zoom lens of the rear focus type of a high variable power ratio can be attained by a large caliber ratio with good optical performance.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1]The lens sectional view of numerical working example 1 of this invention

[Drawing 2]The lens sectional view of numerical working example 2 of this invention

[Drawing 3]The lens sectional view of numerical working example 3 of this invention

[Drawing 4]The aberration figure of the wide angle end of numerical working example 1 of this invention

[Drawing 5]The middle aberration figure of numerical working example 1 of this invention

[Drawing 6]The aberration figure of the tele edge of numerical working example 1 of this invention

[Drawing 7]The aberration figure of the wide angle end of numerical working example 2 of this invention

[Drawing 8]The middle aberration figure of numerical working example 2 of this invention

[Drawing 9]The aberration figure of the tele edge of numerical working example 2 of this invention

[Drawing 10]The aberration figure of the wide angle end of numerical working example 3 of this invention

[Drawing 11]The middle aberration figure of numerical working example 3 of this invention

[Drawing 12]The aberration figure of the tele edge of numerical working example 3 of this invention

[Description of Notations]

L1 The 1st group

L2 The 2nd group

L3 The 3rd group

L4 The 4th group

SP Diaphragm

IP Image surface

deltaM meridional image surface

deltaS sagittal image surface

d d line

g g line

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13/18			13/18	

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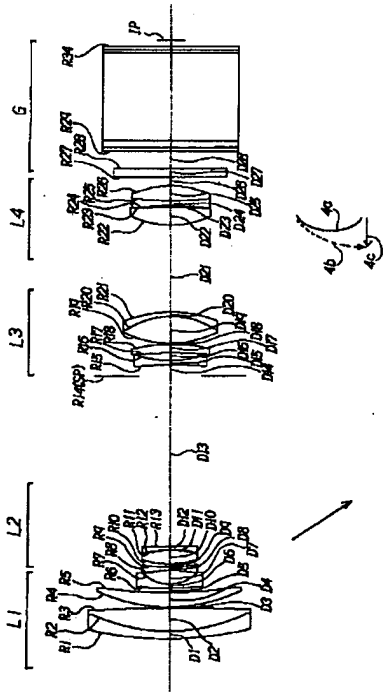
(54)【発明の名称】　リヤーフォーカス式のズームレンズ

(57)【要約】
【課題】　全体として４つのレンズ群を有しバックフォーカスが長く高変倍比を確保しながらも、全ズーム域，全物体距離にわたって良好な性能を有するリヤーフォーカス式のズームレンズを得ること。
【解決手段】　物体側より順に正の屈折力の第１群、負の屈折力の第２群、正の屈折力の第３群、そして正の屈折力の第４群の４つのレンズ群を有し、該第２群を像面側へ移動させて広角端から望遠端への変倍を行い、変倍に伴う像面変動を該第４群を物体側に凸状の軌跡を有しつつ移動させて補正すると共に該第４群を移動させてフォーカスを行い、該第４群は正の第４１レンズ、負の第４２レンズそして正の第４３レンズを有し、該第４群は少なくとも１つの非球面を有し、該第３群の焦点距離ｆ３、広角端における全系のＦナンバーと焦点距離ｆＮＷ，ｆＷ、望遠端における全系の焦点距離ｆＴを各々適切に設定したこと。



【特許請求の範囲】

【請求項１】　物体側より順に正の屈折力の第１群、負の屈折力の第２群、正の屈折力の第３群、そして正の屈折力の第４群の４つのレンズ群を有し、該第２群を像面側へ移動させて広角端から望遠端への変倍を行い、変倍に伴う像面変動を該第４群を物体側に凸状の軌跡を有しつつ移動させて補正すると共に該第４群を移動させてフォーカスを行い、該第４群は正の第４１レンズ、負の第４２レンズそして正の第４３レンズを有し、該第４群は少なくとも１つの非球面を有し、該第３群の焦点距離をｆ３、広角端における全系のＦナンバーと焦点距離を各々ｆＮＷ，ｆＷ、望遠端における全系の焦点距離をｆＴとし、

【数１】

$$fM=\sqrt{fW\cdot fT}$$

とおいたとき

３．４４＜ｆ３×ｆＮＷ／ｆＭ＜１５．３８

なる条件を満足することを特徴とするリヤーフォーカス式のズームレンズ。

【請求項２】　広角端と望遠端における全系の焦点距離を各々ｆＷ，ｆＴ、広角端と望遠端における前記第１群から第３群までの合成の焦点距離を各々ｆＭＷ，ｆＭＴとし、

【数２】

$$fM=\sqrt{fW\cdot fT}$$

$$fAM=\sqrt{fMW\cdot fMT}$$

とおいたとき、

０＜ｆＭ／ｆＡＭ＜１．０

なる条件を満足することを特徴とする請求項１のリヤーフォーカス式のズームレンズ。

【請求項３】　前記第３群は負の第３１レンズ、像面側に凸面を向けたメニスカス状の正の第３２レンズ、そして少なくとも１つの貼り合わせ第３ａレンズを有していることを特徴とする請求項１のリヤーフォーカス式のズームレンズ。

【請求項４】　前記第４群中の少なくとも２つの正レンズの材質のアッベ数をνｄとするとき

νｄ＞６６．５

を満足することを特徴とする請求項１のリヤーフォーカス式のズームレンズ。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明はリヤーフォーカス式のズームレンズに関し、特にレンズ系と撮像素子との間に色分解プリズム等を配置することができる程度の長いバックフォーカスを有した写真用カメラやビデオカメラ、そして放送用カメラ等に用いられる変倍比１５．５，広角端のＦナンバー１．４５～１．６５程度の大口径比で高変倍比のリヤーフォーカス式のズームレンズに関するものである。

【０００２】

【従来の技術】最近、ホームビデオカメラ等の小型軽量化に伴い、撮像用のズームレンズの小型化にも目覚ましい進歩が見られ、特にレンズ全長の短縮化や前玉径の小型化、構成の簡略化に力が注がれている。

【０００３】これらの目的を達成する一つの手段として、物体側の第１群以外のレンズ群を移動させてフォーカスを行う、所謂リヤーフォーカス式のズームレンズが知られている。

【０００４】一般にリヤーフォーカス式のズームレンズは第１群を移動させてフォーカスを行うズームレンズに比べて第１群の有効径が小さくなり、レンズ系全体の小型化が容易になり、又近接撮影、特に極近接撮影が容易となり、更に比較的小型軽量のレンズ群を移動させて行っているので、レンズ群の駆動力が小さくてすみ迅速な焦点合わせができる等の特長がある。

【０００５】このようなリヤーフォーカス式のズームレンズとして、例えば特開昭６２－２１５２２５号公報や、特開昭６２－２０６５１６号公報，特開昭６２－２４２１３号公報，特開昭６３－２４７３１６号公報、そして特開平４－４３３１１号公報では、物体側より順に正の屈折力の第１群、負の屈折力の第２群、正の屈折力の第３群、そして正の屈折力の第４群の４つのレンズ群を有し、第２群を移動させて変倍を行い、第４群を移動させて変倍に伴う像面変動とフォーカスを行った４群タイプのリヤーフォーカス式のズームレンズが提案されている。

【０００６】又、４群タイプのリヤーフォーカス式のズームレンズとして特開平４－４３３１１号公報，特開平４－１５３６１５号公報，特開平５－１９１６５号公報，特開平５－２７１６７号公報及び特開平５－６０９７３号公報では、第４レンズ群を正レンズ１枚又は正レンズ２枚で構成したレンズ全長の短いズームレンズが提案されている。特開平５－６０９７４号公報では、第４レンズ群が正レンズと負レンズの２枚で構成されたズームレンズが提案されている。

【０００７】特開昭５５－６２４１９号公報，特開昭６２－２４２１３号公報，特開昭６２－２１５２２５号公報，特開昭５６－１１４９２０号公報，特開平３－２００１１３号公報，特開平４－２４２７０７号公報，特開平４－３４３３１３号公報，特開平５－２９７２７５号公報等では、その実施例中に第３群と第４群をそれぞれが正レンズと負レンズの２枚のレンズより成るズームレンズを開示している。

【０００８】この他、特開平６－５１１９９号公報，特開平６－３３７３５３号公報，特開平６－３４７６９７号公報，そして特開平７－２７０６８４号公報等ではレンズ系と撮像素子との間に色分解光学系を配置すること

ができる程度の長いバックフォーカスを有したズームレンズが提案されている。

【0009】

【発明が解決しようとする課題】一般にズームレンズにおいてリヤーフォーカス方式を採用するとレンズ系全体が小型化され又迅速なるフォーカスが可能となり、更に近接撮影が容易となる等の特長が得られる。

【0010】しかしながら反面、フォーカスの際の収差変動が大きくなり、無限遠物体から近距離物体に至る物体距離全般にわたり高い光学性能を得るのが大変難しくなってくるという問題点が生じてくる。

【0011】特に大口径比で高変倍のズームレンズでは全変倍範囲にわたり、又物体距離全般にわたり高い光学性能を得るのが大変難しくなってくるという問題点が生じてくる。

【0012】特開平4－43311号公報，特開平4－153615号公報，特開平5－19165号公報，特開平5－27167号公報及び特開平5－60973号公報で開示されているズームレンズではズーム比が6倍から8倍程度であり、これ以上の高変倍比のズームレンズを得ようとすると、変倍による色収差の変動が大きくなりすぎて、これを良好に補正するのが難しくなってくる。又、特開平5－60974号公報で開示されているズームレンズはズーム比が8倍程度で、必ずしも十分ではなかった。

【0013】特開昭55－62419号公報，特開昭56－114920号公報，特開平3－200113号公報で開示されているズームレンズでは、第1群又は第3群が変倍に伴って移動するため鏡筒構造が複雑になり、小型化を達成するのが難しいという問題点があった。

【0014】特開平4－242707号公報及び特開平4－343313号公報，特開平5－297275号公報等に開示されているズームレンズでは第3群が大きな空気間隔を持つレンズ構成となっており、更に第3群中の負レンズの屈折力が弱いため高変倍化のズームレンズに適用しようとすると第3群で色収差が多く発生し、これを充分に補正するのが難しいという問題点があった。

【0015】特開平5－297275号公報で提案されているズームレンズでは、第3群中のメニスカス状の負レンズが像面側に強い凹面を向けたレンズ構成となっているためテレフォト化には有効であるが、正レンズで発生した高次のフレアー成分を該負レンズで補正するのが難しく、大口径化、高変倍化が難しいという問題点があった。

【0016】この他、特開平6－51199号公報，特開平6－337353号公報，特開平6－347697号公報，そして特開平7－270684号公報等で提案されているズームレンズはズーム比が10～12倍程度で、必ずしも十分ではなかった。

【0017】本発明は、4群タイプのリヤーフォーカス式のズームレンズにおいて、各レンズ群のレンズ構成を適切に設定することにより、広角端から望遠端に至る全変倍範囲にわたり、又無限遠物体から超至近物体に至る物体距離全般にわたり、良好なる光学性能を有した大口径比で高変倍比のリヤーフォーカス式のズームレンズの提供を目的とする。

【0018】

【課題を解決するための手段】本発明のリヤーフォーカス式のズームレンズは、物体側より順に正の屈折力の第1群、負の屈折力の第2群、正の屈折力の第3群、そして正の屈折力の第4群の4つのレンズ群を有し、該第2群を像面側へ移動させて広角端から望遠端への変倍を行い、変倍に伴う像面変動を該第4群を物体側に凸状の軌跡を有しつつ移動させて補正すると共に該第4群を移動させてフォーカスを行い、該第4群は正の第41レンズ、負の第42レンズそして正の第43レンズを有し、該第4群は少なくとも1つの非球面を有し、該第3群の焦点距離をf3、広角端における全系のFナンバーと焦点距離を各々fNW，fW、望遠端における全系の焦点距離をfTとし、

【0019】

【数3】

$$fM=\sqrt{fW\cdot fT}$$

とおいたとき

$$3.44<f3\times fNW/fM<15.38 \quad \cdots\cdots (1)$$

なる条件を満足することを特徴としている。

【0020】

【発明の実施の形態】図1～図3は本発明のリヤーフォーカス式のズームレンズの後述する数値実施例1～3のレンズ断面図、図4～図6は数値実施例1，図7～図9は数値実施例2，図10～図12は数値実施例3の諸収差図である。

【0021】収差図において図4，7，10は広角端、図5，8，11は中間、図6，9，12は望遠端を示す。

【0022】図中L1は正の屈折力の第1群、L2は負の屈折力の第2群、L3は正の屈折力の第3群、L4は正の屈折力の第4群である。SPは開口絞りであり、第3群L3の前方に配置している。Gは色分解光学系やフェースプレート、そしてフィルター等のガラスブロックである。IPは像面である。

【0023】本実施例では広角端から望遠端への変倍に際して矢印のように第2群を像面側へ移動させると共に、変倍に伴う像面変動を第4群を物体側に凸状の軌跡を有しつつ移動させて補正している。

【0024】又、第4群を光軸上移動させてフォーカスを行うリヤーフォーカス式を採用している。同図に示す

第４群の実線の曲線４ａと点線の曲線４ｂは各々無限遠物体と近距離物体にフォーカスしているときの広角端から望遠端への変倍に伴う際の像面変動を補正する為の移動軌跡を示している。尚、第１群と第３群は変倍及びフォーカスの際固定である。

【００２５】本実施例においては第４群を移動させて変倍に伴う像面変動の補正を行うと共に第４群を移動させてフォーカスを行うようにしている。特に同図の曲線４ａ，４ｂに示すように広角端から望遠端への変倍に際して物体側へ凸状の軌跡を有するように移動させている。これにより第３群と第４群との空間の有効利用を図りレンズ全長の短縮化を効果的に達成している。

【００２６】本実施例において、例えば望遠端において無限遠物体から近距離物体へフォーカスを行う場合は同図の直線４ｃに示すように第４群を前方へ繰り出すことにより行っている。

【００２７】本発明では物体側より順に該第４群を両レンズ面が凸面の正の第４１レンズ、両レンズ面が凹面又は物体側に凸面を向けたメニスカス状の負の第４２レンズ、そして両レンズ面が凸面の正の第４３レンズの３つのレンズより構成すると共に条件式（１）を満足していることを特徴としている。

【００２８】第４群を以上の如く３つのレンズより構成することによって、射出瞳の位置（距離）を長くして、レンズ系からの射出光束がテレセントリックとなるようにして、レンズ系の後方に、例えば３Ｐプリズム等の色分解光学系を配置したときの光束の入射角度が緩くなるようにして色分解を良好に行い画像の色再現性を高めるようにしている。

【００２９】そして所定の長さのバックフォーカスを確保しつつ大口径化及び高変倍化を図る際の収差を良好に補正する為に第３群の屈折力（焦点距離ｆ３）とＦナンバーとが条件式（１）を満足するように各要素を設定している。

【００３０】この条件式（１）は第３群の焦点距離ｆ３を規制するもので、バックフォーカスと大きく関係してくる。

【００３１】条件式（１）の下限値を越えて広角端のＦナンバーＦＮＷを明るくしたり、第３群の焦点距離を短くすると所定の長さのバックフォーカスを確保するのが難しくなってくる。逆に上限値を越えて第３群の焦点距離をむやみに長くしたり、広角端のＦナンバーＦＮＷを暗くすると、バックフォーカスは長くなるが、第４群との距離が長くなり、レンズ全長が長くなり、小型化が難しくなってくる。

【００３２】本発明のリヤーフォーカス式のズームレンズのこの他のレンズ構成の特徴について説明する。

【００３３】（イ）本発明は、高変倍を１つの目的としており、この為には変倍に伴って発生する色収差は第１群及び第２群においてキャンセルすることが望ましい。しかるに変倍に伴う倍率の色収差の発生の仕方は第１群と第２群のそれとでは大きく異なり、広角端では補正過剰の傾向となりやすい。従って第４群の倍率の色収差を補正不足とすることにより全体としての色収差のバランスを保っている。

【００３４】この場合、軸上の色収差は変倍比が小さいときは大きくバランスを崩すことなく補正することが可能である。従って第３群を正の単一のレンズとすることも可能であるが、本発明の如く高変倍，大口径をねらう場合、軸上の色収差が全体として補正不足となり高い性能を維持することが困難となる。

【００３５】そこで本発明では第３群を負の第３１レンズ、像面側に凸面を向けたメニスカス状の正の第３２レンズ、そして少なくとも１つの貼り合わせ第３ａレンズより構成することにより全変倍範囲にわたり最適に色収差を補正している。また高次のフレアー成分を持つ球面収差を小さく抑えている。

【００３６】特に第３群を両レンズ面が凹面又は物体側に凸面を向けたメニスカス状の負の第３１レンズ、像面側に凸面を向けたメニスカス状の正の第３２レンズ、両レンズ面が凸面の正の第３３レンズ、そして像面側に凸面を向けたメニスカス状の負の第３４レンズより構成し、このうち第３３レンズと第３４レンズとを接合した貼り合わせレンズとしている。

【００３７】このように本発明では簡単なレンズ構成でありながら変倍比１５．５，広角端のＦナンバー１．４５～１．６５程度と、高変倍比及び大口径で、しかも高い光学性能を維持している。

【００３８】（ロ）基本的に各群のレンズ構成においてレンズを接合する構成をとると、群内偏心を効果的に抑制可能であり製品性能の安定化を図ることが可能であるが、設計の自由度が１つ減り、大口径，小型ズームという仕様を満足しつつ充分な初期性能を達成することが困難となる。

【００３９】そこで本発明では第３群を前述の如く構成すると共に数値実施例１では第３群中の最も強い正の屈折力の凸面にレンズ周辺にいくに従って正の屈折力が弱くなる形状の非球面を施すことにより、球面収差の高次のフレアー成分を補正すると共に群内偏心等の抑制が効果的に行われ、より精度の高いズームレンズで大口径化を達成している。また図１，図３の数値実施例１，３では第４群を接合レンズを有するように構成することにより第３群と同様に群内偏心等の抑制が効果的に行われ、より精度の高いズームレンズを達成している。

【００４０】又本発明では第４群中の最も強い正の屈折力の凸面にレンズ周辺部にいくに従って正の屈折力が弱くなる形状の非球面を採用することにより球面収差と非点収差を補正して大口径，超高倍のズームレンズでありながらも精度の高いズームレンズを達成している。

【００４１】（ハ）広角端と望遠端における全系の焦点

距離を各々ｆＷ，ｆＴ、広角端と望遠端における前記第１群から第３群までの合成の焦点距離を各々ｆＭＷ，ｆＭＴとし、

【００４２】

【数４】

$$fM=\sqrt{fW\cdot fT}$$

$$fAM=\sqrt{fMW\cdot fMT}$$

とおいたとき、

０＜ｆＭ／ｆＡＭ＜１．０　　……（２）

なる条件を満足することである。

【００４３】条件式（２）は第３群からの光線束の収斂度合いを意味するものである。一般的に変倍部で発散された光線束を第３群で略アフォーカルにすることが最も安定した収差補正方法である。しかしながら第３群から出てくる光線束を略平行光線にすると、レンズ全長の短縮化が難しくなってくる。そこで本発明では条件式（２）を満足させることにより、第３群から射出される光線束を収斂光線として更なるレンズ全長の短縮化を図っている。

【００４４】条件式（２）の意味は、即ち下限値を越えると光線束は発散系となりレンズ全長がのび、更に第４群への入射光線の高さも高くなるため第４群が大型化するため好ましくない。また上限値を越えると収斂度が大きくなり小型化には効果が上がるズーミング及びフォーカシングによる収差変動が大きくなり、ズーム全域で良好な収差補正を行うことが困難となる。

【００４５】尚、本発明において条件式（２）の上限値を、

０＜ｆＭ／ｆＡＭ＜０．３　　……（２ａ）

とすれば、更に安定した収差補正とレンズ全長の短縮化の両立が容易となる。

【００４６】（ニ）前記第４群中の少なくとも２つの正レンズの材質のアッベ数をνｄとするとき

νｄ＞６６．５　　……（３）

を満足することである。

【００４７】条件式（３）は主に変倍に伴う色収差の変動、特に倍率色収差の変動を良好に補正する為のものである。条件式（３）を外れると倍率色収差が補正不足となってくるので良くない。

【００４８】次に本発明の数値実施例を示す。数値実施例においてＲｉは第１共役点側より順に第ｉ番目のレンズ面の曲率半径、Ｄｉは第１共役点側より第ｉ番目のレンズ厚及び空気間隔、Ｎｉとνｉは各々第１共役点側より順に第ｉ番目のレンズのガラスの屈折率とアッベ数である。但し、数値実施例１，３におけるＲ２７～Ｒ３４，数値実施例２におけるＲ２８～Ｒ３５のレンズ面は色分解光学系，フェースプレート，フィルター等のガラスブロックを示している。

【００４９】非球面形状は光軸方向にＸ軸、光軸と垂直方向にＹ軸、光の進行方向を正としＲを近軸曲率半径、Ｋ，Ｂ，Ｃ，Ｄ，Ｅを各々非球面係数としたとき、

【００５０】

【数５】

$$X=\frac{(1/R)\,Y^2}{1+\sqrt{1-(1+K)\,(Y/R)^2}}+BY^4+CY^6+DY^8+EY^{10}$$

なる式で表わしている。また「ｅ－０ｘ」は「１０$^{-x}$」を意味している。又前述の各条件式と数値実施例における諸数値の関係を表－１に示す。

【００５１】

【外１】

[数値実施例1]

f＝1～15.41 Fno＝1.65～2.65 2ω＝55.9～4.0

R 1 =	14.679	D 1 =	0.80	N 1 =	1.846660	ν 1 =	23.8
R 2 =	7.315	D 2 =	0.94	N 2 =	1.603112	ν 2 =	60.7
R 3 =	-59.942	D 3 =	0.04				
R 4 =	6.825	D 4 =	0.58	N 3 =	1.696797	ν 3 =	55.5
R 5 =	20.017	D 5 =	可変				
R 6 =	14.839	D 6 =	0.16	N 4 =	1.882997	ν 4 =	40.8
R 7 =	1.570	D 7 =	0.56				
R 8 =	-5.096	D 8 =	0.14	N 5 =	1.882997	ν 5 =	40.8
R 9 =	7.898	D 9 =	0.11				
R10 =	3.394	D10 =	0.55	N 6 =	1.846660	ν 6 =	23.8
R11 =	-5.130	D11 =	0.02				
R12 =	-4.356	D12 =	0.14	N 7 =	1.772499	ν 7 =	49.6
R13 =	51.492	D13 =	可変				
R14 =	絞り	D14 =	0.45				
R15 =	-14.996	D15 =	0.18	N 8 =	1.804000	ν 8 =	46.6
R16 =	4.405	D16 =	0.30				
R17 =	-13.173	D17 =	0.35	N 9 =	1.603420	ν 9 =	38.0
R18 =	-6.245	D18 =	0.03				
＊R19 =	4.034	D19 =	1.08	N10 =	1.583126	ν10 =	59.4
R20 =	-8.937	D20 =	0.18	N11 =	1.696797	ν11 =	55.5
R21 =	-5.032	D21 =	可変				
R22 =	8.666	D22 =	0.71	N12 =	1.487490	ν12 =	70.2
R23 =	-51.198	D23 =	0.09				
R24 =	-9.824	D24 =	0.18	N13 =	1.846660	ν13 =	23.8
R25 =	13.203	D25 =	0.62	N14 =	1.487490	ν14 =	70.2
＊R26 =	-8.269	D26 =	0.35				
R27 =	∞	D27 =	0.35	N15 =	1.516330	ν15 =	64.2
R28 =	∞	D28 =	0.71				
R29 =	∞	D29 =	0.14	N16 =	1.550000	ν16 =	60.0
R30 =	∞	D30 =	0.28	N17 =	1.520000	ν17 =	69.0
R31 =	∞	D31 =	3.54	N18 =	1.589130	ν18 =	61.2
R32 =	∞	D32 =	0.10	N19 =	1.550000	ν19 =	60.0
R33 =	∞	D33 =	0.14	N20 =	1.516330	ν20 =	64.2
R34 =	∞						

焦点距離 / 可変間隔	W 1.00	M 7.25	T 15.41
D 5	0.17	5.71	6.76
D13	6.89	1.35	0.30
D21	3.53	2.55	3.50

非球面係数

R19 k=2.178 e-01 B=-2.194 e-03 C=-2.387 e-04 D=4.520 e-05 E=-8.647 e-06

R26 k=-4.680 e+00 B=-5.845 e-03 C=1.788 e-03 D=-2.926 e-04 E=3.446 e-05

【0052】

【外2】

[数値実施例2]

f = 1～15.53 Fno = 1.65～2.85 2ω=55.9～3.9

R 1 =	13.255	D 1 =	0.30	N 1 = 1.846660	ν 1 = 23.8
R 2 =	6.913	D 2 =	0.92	N 2 = 1.603112	ν 2 = 60.7
R 3 =	-360.605	D 3 =	0.04		
R 4 =	6.814	D 4 =	0.58	N 3 = 1.712995	ν 3 = 53.8
R 5 =	20.071	D 5 =	可変		
R 6 =	11.811	D 6 =	0.16	N 4 = 1.882997	ν 4 = 40.8
R 7 =	1.523	D 7 =	0.62		
R 8 =	-4.581	D 8 =	0.14	N 5 = 1.882997	ν 5 = 40.8
R 9 =	10.887	D 9 =	0.14		
R10 =	3.642	D10 =	0.48	N 6 = 1.846660	ν 6 = 23.8
R11 =	-6.095	D11 =	0.01		
R12 =	-6.929	D12 =	0.14	N 7 = 1.772499	ν 7 = 49.6
R13 =	18.541	D13 =	可変		
R14 =	絞り	D14 =	0.40		
R15 =	46.905	D15 =	0.18	N 8 = 1.603112	ν 8 = 60.7
R16 =	3.987	D16 =	0.44		
R17 =	-5.638	D17 =	0.27	N 9 = 1.603420	ν 9 = 38.0
R18 =	-4.309	D18 =	0.04		
R19 =	4.653	D19 =	0.87	N10 = 1.603420	ν10 = 38.0
R20 =	-4.358	D20 =	0.18	N11 = 1.805181	ν11 = 25.4
R21 =	-9.396	D21 =	可変		
R22 =	4.018	D22 =	0.81	N12 = 1.487490	ν12 = 70.2
R23 =	-6.241	D23 =	0.03		
R24 =	-14.229	D24 =	0.18	N13 = 1.846660	ν13 = 23.8
R25 =	8.079	D25 =	0.04		
R26 =	7.167	D26 =	0.65	N14 = 1.487490	ν14 = 70.2
* R27 =	-4.952	D27 =	0.35		
R28 =	∞	D28 =	0.35	N15 = 1.516330	ν15 = 64.2
R29 =	∞	D29 =	0.71		
R30 =	∞	D30 =	0.14	N16 = 1.550000	ν16 = 50.0
R31 =	∞	D31 =	0.28	N17 = 1.520000	ν17 = 59.0
R32 =	∞	D32 =	3.54	N18 = 1.589130	ν18 = 61.2
R33 =	∞	D33 =	0.10	N19 = 1.550000	ν19 = 50.0
R34 =	∞	D34 =	0.14	N20 = 1.516330	ν20 = 64.2
R35 =	∞				

焦点距離 / 可変間隔	W 1.00	M 7.46	T 15.53
D 5	0.18	5.86	6.94
D13	7.08	1.98	0.30
D21	3.13	2.18	3.15

非球面係数

R27 k=-1.142 e+01 B=-2.587 e-03 C=1.357 e-03 D=2.224 e-05 E=-2.530 e-05

【0053】 【外3】

[数値実施例3]

f＝1～15.56　Fno＝1.45～2.35　2ω＝55.9～3.9

R 1 =	16.744	D 1 =	0.34	N 1 = 1.846660	ν 1 = 23.8
R 2 =	8.080	D 2 =	1.04	N 2 = 1.603112	ν 2 = 60.7
R 3 =	-52.875	D 3 =	0.04		
R 4 =	6.788	D 4 =	0.65	N 3 = 1.712995	ν 3 = 53.8
R 5 =	16.145	D 5 =	可変		
R 6 =	11.275	D 6 =	0.16	N 4 = 1.882997	ν 4 = 40.8
R 7 =	1.652	D 7 =	0.69		
R 8 =	-4.456	D 8 =	0.14	N 5 = 1.882997	ν 5 = 40.8
R 9 =	23.809	D 9 =	0.11		
R10 =	3.944	D10 =	0.50	N 6 = 1.846660	ν 6 = 23.8
R11 =	-6.752	D11 =	0.01		
R12 =	-6.014	D12 =	0.12	N 7 = 1.772499	ν 7 = 49.6
R13 =	22.181	D13 =	可変		
R14 =	絞り	D14 =	0.95		
R15 =	-75.499	D15 =	0.16	N 8 = 1.603112	ν 8 = 60.7
R16 =	3.992	D16 =	0.42		
R17 =	-11.584	D17 =	0.32	N 9 = 1.603420	ν 9 = 38.0
R18 =	-5.605	D18 =	0.04		
R19 =	4.523	D19 =	1.06	N10 = 1.603420	ν10 = 38.0
R20 =	-4.495	D20 =	0.16	N11 = 1.834807	ν11 = 42.7
R21 =	-12.558	D21 =	可変		
R22 =	3.954	D22 =	0.87	N12 = 1.487490	ν12 = 70.2
R23 =	-13.219	D23 =	0.04		
R24 =	7.326	D24 =	0.16	N13 = 1.846660	ν13 = 23.8
R25 =	2.531	D25 =	1.06	N14 = 1.487490	ν14 = 70.2
＊R26 =	-6.095	D26 =	0.35		
R27 =	∞	D27 =	0.35	N15 = 1.516330	ν15 = 64.2
R28 =	∞	D28 =	0.53		
R29 =	∞	D29 =	0.14	N16 = 1.550000	ν16 = 60.0
R30 =	∞	D30 =	0.28	N17 = 1.520000	ν17 = 69.0
R31 =	∞	D31 =	0.54	N18 = 1.589130	ν18 = 61.2
R32 =	∞	D32 =	0.10	N19 = 1.550000	ν19 = 60.0
R33 =	∞	D33 =	0.14	N20 = 1.516330	ν20 = 64.2
R34 =	∞				

焦点距離 / 可変間隔	W 1.00	M 7.87	T 15.56
D 5	0.17	6.17	7.32
D13	7.43	1.43	0.28
D21	2.16	1.22	2.20

非球面係数

R26 k=-8.511 e+00 B=1.358 e-03 C=-3.565 e-04 D=3.843 e-04 E=-4.533 e-05

【0054】

【表1】

表－1

条件式	数値実施例		
	1	2	3
(1)	3.82	4.72	5.30
(2)	0.18	0.06	0.013
(3)	70.2	70.2	70.2

【0055】

【発明の効果】本発明によれば以上のように、4群タイプのリヤーフォーカス式のズームレンズにおいて、各レンズ群のレンズ構成を適切に設定することにより、広角端から望遠端に至る全変倍範囲にわたり、又無限遠物体から超至近物体に至る物体距離全般にわたり、良好なる光学性能を有した大口径比で高変倍比のリヤーフォーカス式のズームレンズを達成することができる。

【図面の簡単な説明】

【図1】本発明の数値実施例1のレンズ断面図

【図2】本発明の数値実施例2のレンズ断面図

【図3】本発明の数値実施例3のレンズ断面図

【図4】本発明の数値実施例1の広角端の収差図

【図5】本発明の数値実施例1の中間の収差図

【図6】本発明の数値実施例1の望遠端の収差図

【図7】本発明の数値実施例2の広角端の収差図

【図8】本発明の数値実施例2の中間の収差図

【図9】本発明の数値実施例2の望遠端の収差図

【図10】本発明の数値実施例3の広角端の収差図

【図11】本発明の数値実施例3の中間の収差図

【図12】本発明の数値実施例3の望遠端の収差図

【符号の説明】

L1　第1群

L2　第2群

L3　第3群

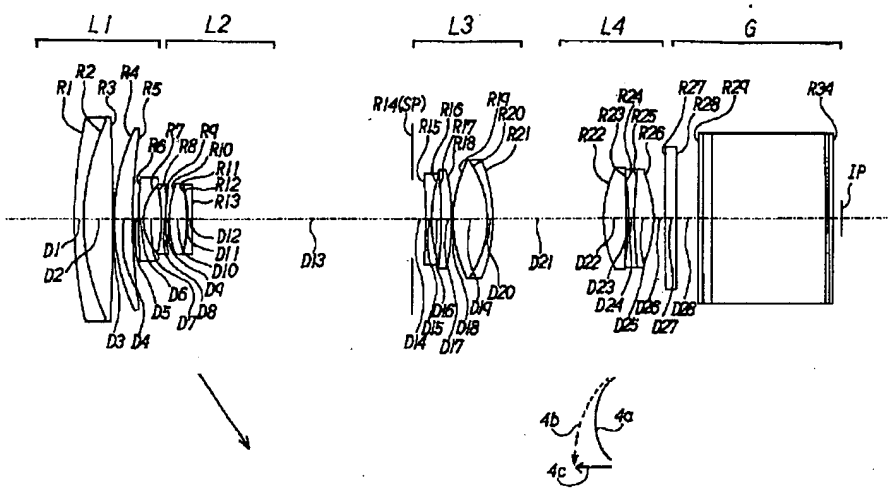
L4　第4群

SP　絞り

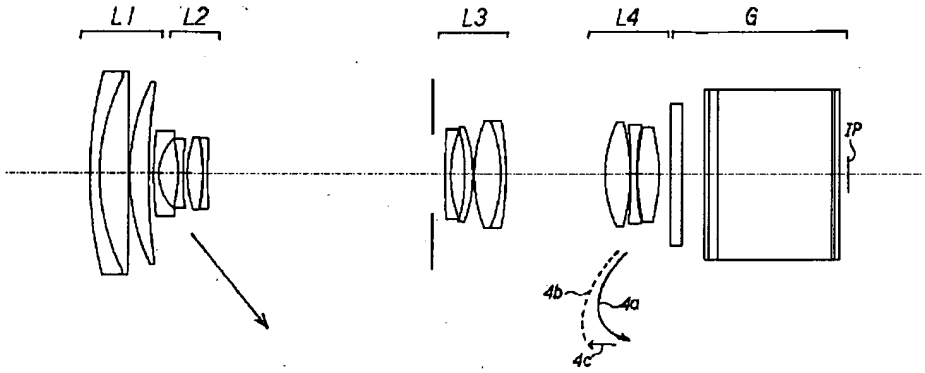
IP　像面

ΔM　メリディオナル像面　　d　d線
ΔS　サジタル像面　　g　g線

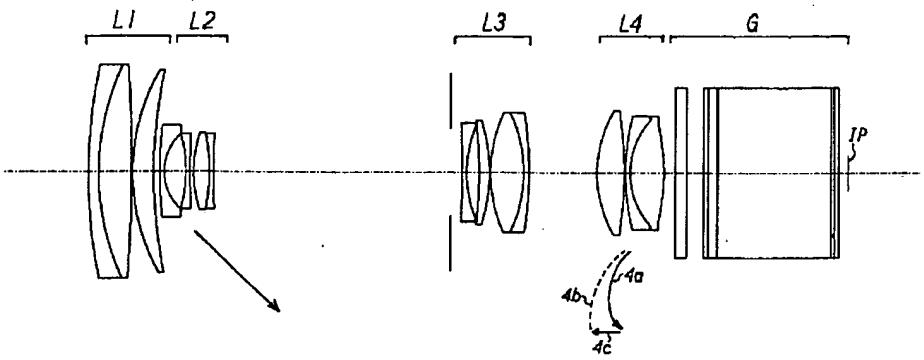
【図1】



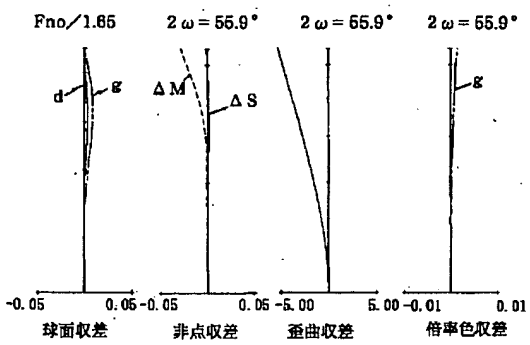
【図2】



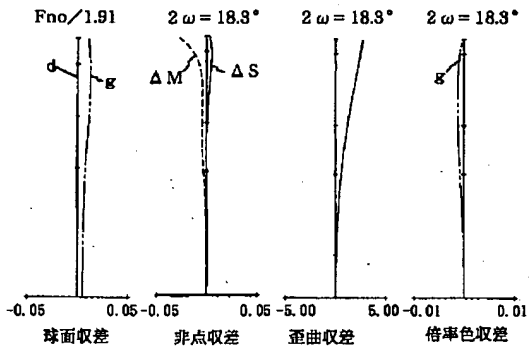
【図3】



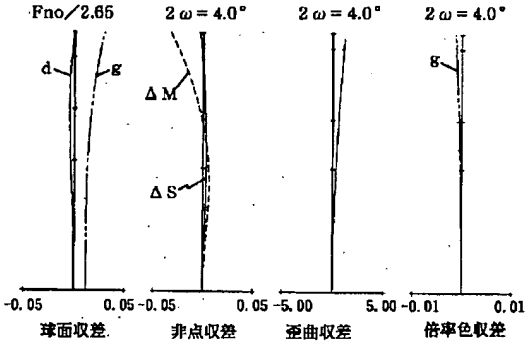
【図4】



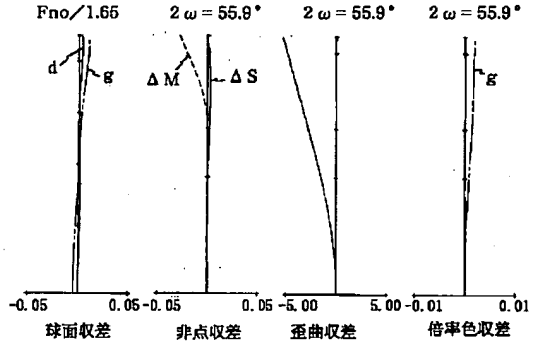
【図5】



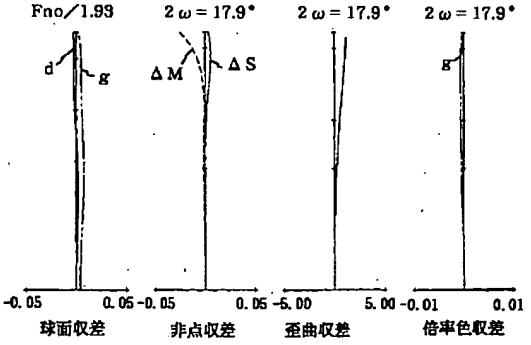
【図6】



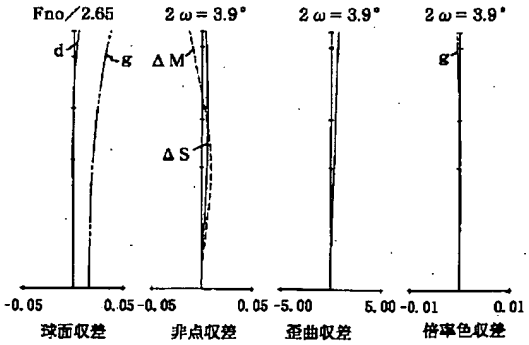
【図7】



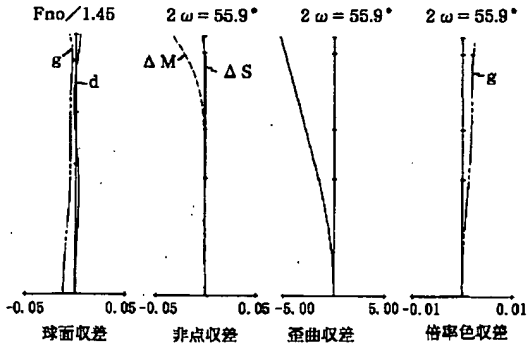
【図8】



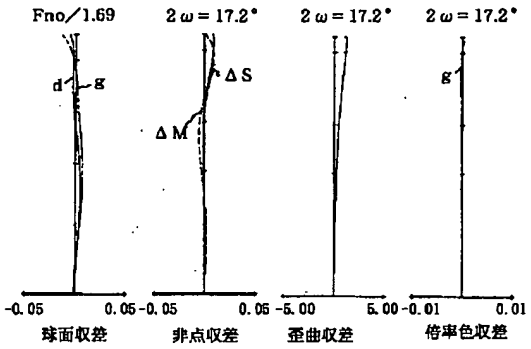
【図9】



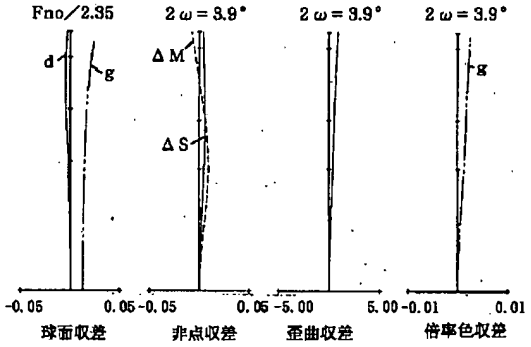
【図１０】


Fno／1.45
2ω＝55.9°
2ω＝55.9°
2ω＝55.9°
g
d
ΔM
ΔS
g
-0.05
0.05
-0.05
0.05
-5.00
5.00
-0.01
0.01
球面収差
非点収差
歪曲収差
倍率色収差

【図１１】


Fno／1.69
2ω＝17.2°
2ω＝17.2°
2ω＝17.2°
d
g
ΔS
ΔM
g
-0.05
0.05
-0.05
0.05
-5.00
5.00
-0.01
0.01
球面収差
非点収差
歪曲収差
倍率色収差

【図１２】


Fno／2.35
2ω＝3.9°
2ω＝3.9°
2ω＝3.9°
d
g
ΔM
ΔS
g
-0.05
0.05
-0.05
0.05
-5.00
5.00
-0.01
0.01
球面収差
非点収差
歪曲収差
倍率色収差